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## POSTURAL SWAY FOLLOWING CRYOTHERAPY IN HEALTHY ADULTS.

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### INTRODUCTION

Cryotherapy (cold water immersion) has been widely employed in rehabilitation programs to improve exercise tolerance and provide analgesia to patients and athletes prior to exercise [1]. However, cryotherapy has also been reported to decrease proprioception, which could increase postural sway [2]. Since the maintenance of balance and posture is paramount to perform daily physical activities and postural stability deficits have been associated with an increased incidence of ankle injuries [3,4], it is important to understand the effect of cryotherapy on postural sway.

The purpose of this study was to analyze the effects of 20 minutes of cold water immersion on postural body sway during bipedal and unipedal quiet standing conditions. We hypothesized that postural sway would increase after cryotherapy.

### METHODS

Twenty six healthy males were recruited and randomly assigned to either an intervention group (cold water at ~ 11°C) or control group (tepid water at ~ 26°C). Thirteen subjects were placed in the intervention group (age: 22.9 ± 3.1 years; height: 177.2 ± 10.2 cm; mass: 72.1 ± 7.2 kg) and thirteen in the control group (age: 26.8 ± 3.9 years; height: 176.9 ± 6.1 cm; mass: 75.6 ± 8.1 kg). All subjects provided informed consent prior to participation.

During the balance task, each subject was required to stand on the force plate on their right leg for 40 seconds (unipedal quiet standing) and on both legs for 70 seconds (bipedal quiet standing). For the unipedal condition, the right leg was placed on the middle of the force plate. During the bipedal condition, feet were abducted at 30° and with 3 cm distance between the heels. Three trials per condition were collected. Subjects were required to stand as still as possible with their arms at their sides in a comfortable position, and looking at a point about 4 m straight ahead at their eye level. After the baseline data collection, they were asked to remain sitting in a water tub for 20 minutes, immersed up to the umbilical level. After the intervention, the same measurements were repeated to define the effect of the water temperature. The total time after the water intervention and the first post-intervention trial was approximately nine minutes.

Ground reaction forces were collected with a Kistler Force Plate (Kistler Instrument AG, Winterthur) at 60 Hz. The center of pressure (COP) in the anterior-posterior (AP) and medio-lateral (ML) position was computed for further

analysis. The data were filtered at 10 Hz using a fourth order low-pass Butterworth filter. The COP area was estimated by fitting an ellipse using principal component analysis that involved 95% of the COP data. The COP speed in the anterior-posterior (AP) and medio-lateral (ML) direction was defined as the total COP displacement divided by the total length of the trial.

The median across trials for each variable was obtained for each subject and it was used in the statistical analysis. A 2x2 mixed factorial ANOVA was applied, with factors group (Control and Ice) and time (Pre and Post). All statistical analysis data were performed in R software (version 2.15.1) and an alpha of 0.05 was used for all statistically significant tests.

Additionally, the ratio between post/pre in both groups was analyzed and a statistical t-test with  $p < 0.05$  was considered to detect significant differences.

### RESULTS AND DISCUSSION

The main ANOVA showed a statistically significant interaction between groups and time for the COP speed AP in the bipedal condition ( $F(12,24)=4.475$ ;  $p=0.04$ ). For the unipedal condition, the ANOVA revealed a main effect of time ( $F(1,24)=14.07$ ;  $p < 0.01$ ), and a statistically significant interaction between factors ( $F(1,24)=13.73$ ;  $p < 0.01$ ), where following cryotherapy a higher COP speed AP was found ( $p < 0.01$ ). Furthermore, COP speed ML in the bipedal condition revealed an ANOVA main effect of time ( $F(1,24)=6.459$ ;  $p=0.02$ ), with statistically significant interaction ( $F(1,24)=10.122$ ;  $p < 0.01$ ), and a higher COP speed ML in the ice group ( $p=0.01$ ). For the unipedal condition, the COP speed ML presented a statistically significant group vs. time interaction ( $F(1,24)=11.32$ ;  $p < 0.01$ ), where higher COP speed ML was found after cryotherapy ( $p=0.02$ ). There were no significant differences for the COP area during bipedal and unipedal conditions (Figure 1).

Differences between the ratio in the control and ice groups showed a trend where following cryotherapy the COP speed increased significantly during both conditions. Statistically significant differences are shown in Table 1.

The increased COP speed in the AP and ML directions could potentially be attributed to alterations in the somatosensory inputs from joints, muscles, and cutaneous stimulation [5]. A previous study also reported a decrease in

the afferent muscle-fiber conduction velocity, which may alter the proprioception input, decreasing the postural stability [5]. Therefore, the increase in the COP speed following cryotherapy could be a response to the changes in proprioception. In fact, McKeon and Hertel [6] reported that the plantar cutaneous receptors in the foot after immersion cryotherapy would play an important role in the postural sway deficits.

As clinical studies revealed that small changes in the COP speed would reflect a better balance, higher COP speed could also be associated with pathologies or a higher risk of falls in the elderly population [7]. Additionally, individuals with decreased postural stability are more likely to sustain ankle injuries [4].

## CONCLUSIONS

Postural sway changed following the application of cryotherapy. COP speed in the AP and ML direction was higher during bipedal and unipedal quiet standing in healthy adults. Despite its increased popularity among athletes to speed up the recovery from injuries, this is the first study to

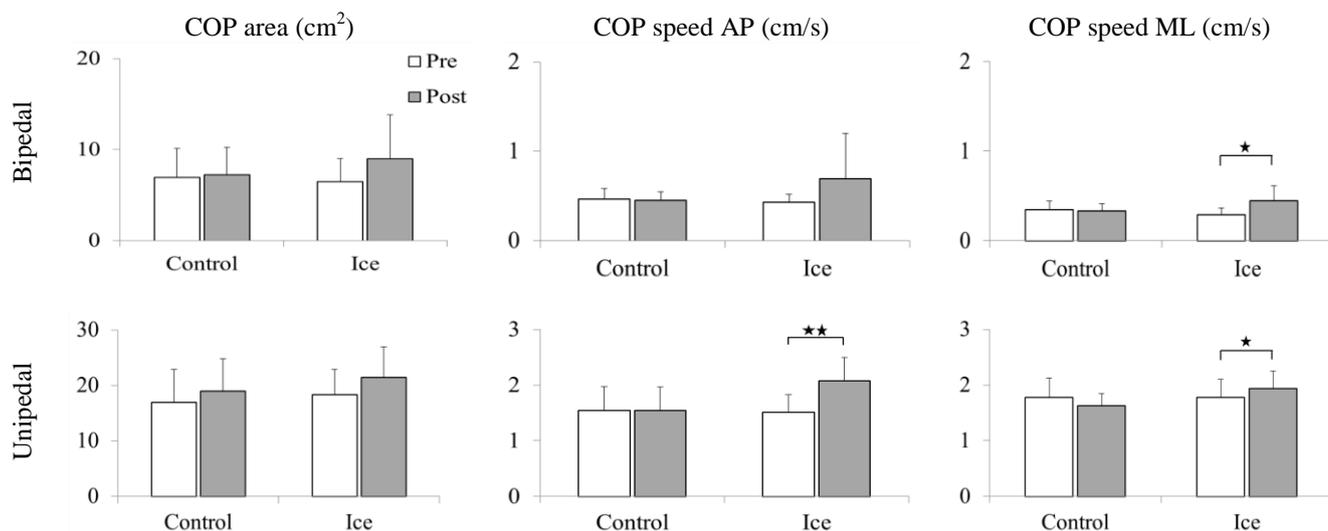
explore the effects of cold immersion of the whole lower limb on postural sway. These potential negative effects need further investigation, particularly in injured subjects.

## ACKNOWLEDGEMENTS

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**Figure 1.** Mean and standard deviation values of COP area, COP speed AP and ML between Control and Ice groups for the bipedal and unipedal conditions, \* $p<0.05$ , \*\* $p<0.01$ .

**Table 1.** Ratio post/pre for the Control and Ice groups. Statistically significant differences between groups are shown ( $p<0.05$ ).

Variables		Control	Ice	<i>p</i> -value
Bipedal	COP area (cm <sup>2</sup> )	1.18 ± 0.68	1.49 ± 0.81	0.38
	COP speed AP (cm/s)	0.98 ± 0.15	1.57 ± 0.85	<b>0.03</b>
	COP speed ML (cm/s)	0.96 ± 0.09	1.62 ± 0.73	<b>0.01</b>
Unipedal	COP area (cm <sup>2</sup> )	1.20 ± 0.39	1.20 ± 0.32	0.95
	COP speed AP (cm/s)	1.02 ± 0.18	1.41 ± 0.36	<b>0.01</b>
	COP speed ML (cm/s)	0.93 ± 0.14	1.10 ± 0.13	<b>0.03</b>